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IMPACT OF DDT SPRAYING ON MALARIA TRANSMISSION IN DIFFERENT AREAS OF JAVA WHERE THE VECTOR A. ACONITUS IS RESISTANT TO DDT

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Di Jawa dan Bali vektor utama yang berperanan terhadap transmissi penyakit adalah A. aconitus yang berkembang biak dipersawahan dan A. sundaicus yang berkembang biak diair payau. Resistensi A. aconitus terhadap dieldrin mulai timbul pada tahun 1959 (Subah, Jawa Tengah) dan mulai tahun 1962 juga resistent terhadap DDT (double resistent). Resistensi terhadap DDT dari tahun ketahun makin meluas didaerah pedalaman di Jawa Tengah bahkan meluas sampai dipedalaman Jawa Timur yang berbatasan dengan Jawa Tengah. Karena DDT masih merupakan racun serangga yang paling murah untuk program pemberantasan malaria, maka dilaksanakan percobaan untuk mengetahui sampai berapa jauh manfaat penyemportan dengan DDT didaerah dimana vektornya telah resistent terhadap racun serangga tersebut. Penelitian dilaksanakan didua daerah di kabupaten Magetan Jawa Timur dan Kabupaten Bantul, Yogyakarta.

Hasil penelitian yang diperoleh di Magetan baik dari hasil parasite survey, case detection, maupun pengamatan entomologi menunjukkan bahwa terjadi kenaikan jumlah penderita.
Kenaikan P.R. dan S.P.R. didaerah yang tidak disemprot jauh lebih besar daripada daerah yang disemprot. Di Bantul terjadi penurunan jumlah penderita baru yang meyakinkan di daerah yang disemprot (323 pada tahun 1972 menjadi 75 pada tahun 1973).

Dari hasil yang dicapai terlihat bahwa meskipun vektor telah resistent terhadap DDT masih ada effek dari penyemportan berupa penurunan "man/vector contact", "indoor resting" dan umur nyamuk pendek yang mempengaruhi "basic reproduction rate" dari penyakit malaria. Di Magetan dimana manusia dan hewan tinggal dalam bangunan yang sama, hasilnya dapat diharapkan akan kecil bila dibandingkan dengan Yogyakarta, dimana hewan tinggal dikandang terbuka yang terpisah jauh. Penghapusan terhadap DDT yang telah disemprotkan di Magetan juga cukup berarti terutama di rumah-rumah yang bagus. Faktor-faktor ini dapat menerangkan mengapa hasil yang kurang baik di Magetan.

Dengan demikian dapat disimpulkan bahwa situasi setempat kiranya menyebabkan perbedaan hasil ini. Ditempat dimana hewan ditaruh terpisah dari manusia, perubahan kecil dari man/vector contact sudah cukup untuk mengurangi penularan. Sebaliknya ditempat dimana hewan dan manusia tinggal pada tempat yang berdekatan, perobahan man/vector contact tidak cukup untuk memberikan pengurangan terhadap penularan. Pada keadaan yang demikian perlu dipakai racun serangga lain yang mengakibatkan kematian yang tinggi terhadap vektor.

In Java there are 2 principal vectors of malaria *Anopheles aconitus* and *A. sundaicus*. *A. sundaicus* is limited to the south coast where it breeds in the brackish water of the lagoons or in the closed mouths of rivers. *A. aconitus* is the most widely spread vector with its distribution from the coastal plain at sea level to the central plateau up to an altitude of approximately 1200 m. It is a typical rice field breeder which usually reaches a peak density around March – April – May. The species is largely

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zoophilic and mainly associated with cattle and water buffaloes. It is considered to be highly exophilic and found mostly resting in hollows along stream banks (Sundararaman et al, 1957).

Development of resistance to dieldrin was first reported from Subah (Central Java) in 1959 after 3 years of spraying (6 rounds at 0,5 g/m2). During the period 1962 – 1964 double resistance (DDT–dieldrin) was reported from large areas of Java (Soerono, Davidson and Muir, 1965).

A. aconitus is now resistant to DDT over large areas of Central Java including Yogyakarta Provice and is spreading to the east in the Province of East Java (O'Connor and Arawati, 1974). The level of resistance is high, 90 per cent of susceptibility tests performed in Central Java have given less than 50 per cent mortality using 4 per cent DDT impregnated papers (see Fig 1).

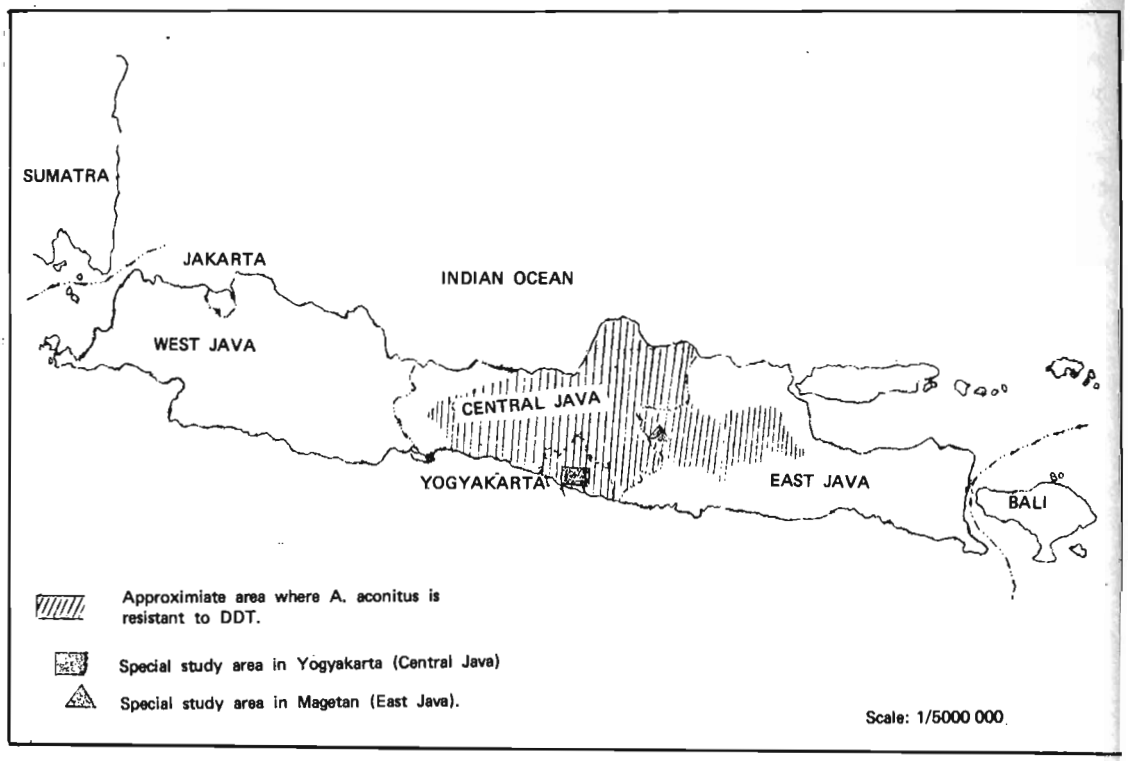

Fig. 1 DDT Resistance in *A. aconitus* in Java and location of study areas

Due to lack of DDT, spraying was carried out on focal basis (kampung size) and results were inconclusive so it was therefore decided in 1972 to assess the impact of DDT by covering continuous areas with a population of at least 50,000 in each.

MATERIALS AND METHODS

Two study areas were selected, one in the eastern part of Java (Magetan), the other one in the central part (Bantul, Yogyakarta). Selection was based on high vector resistance, high incidence and easy accessibility.

In Magetan it was decided that the basic method to assess the impact of attack measures would be based on serial parasite surveys and on the existing limited case detection activities.

In Bantul, Yogyakarta, where case detection was adequate and incidence lower, it was decided that the basic method of assessment would be based on surveillance activities (active and passive case detections, epidemiological investigations).

In the study protocol it was also stated that "this assessment supported by entomological studies of the components of the vectorial capacity. There are difficulties in application of entomological techniques but this entomological approach can still be valuable" Prior to spraying, each house was numbered and sketch maps prepared. Both areas were sprayed at 6 monthly intervals in January and July. The spraying cycle lasted approximately 1 month. Efforts were made to ensure the best coverage, however higher parts of walls and ceilings were usually not sprayed as extension lances were not available. It should be noted that during the eradication campaign (1959–1965) no extension lances were used. The average quantity used per house was respectively 1 kg DDT w.p. 75 per cent in Magetan and 0.8 kg in Yogyakarta. The rate of application was 2 g/m2.

RESULTS

Magetan (East Java).

The serial parasite surveys carried out respectively in 1972 and 1973 in the sprayed area (Panekan) are summarized in the following table 1 and Figure II.

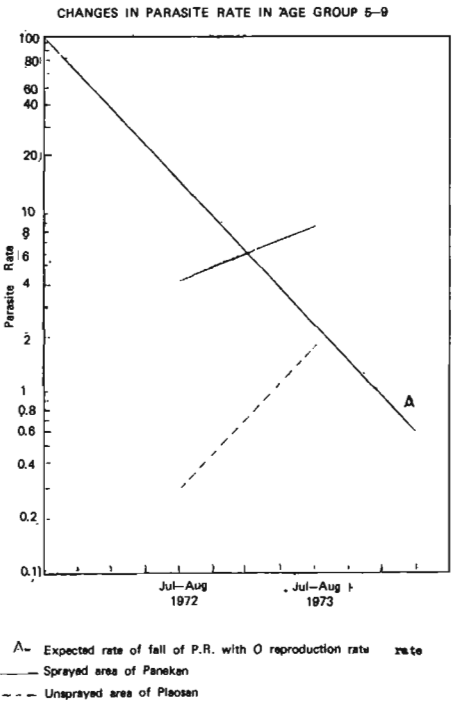

Fig. II. Results of serial parasite surveys in Magetan special study area (East Java).

Table 1 Survey results in Panekan (1972 and 1973)

Date	Age (years)	No. of slides		Per cent Pos.	Parasite species		
		Exam	Pos		F	V	Mix
1972	5–9	1706	72	4.2	15	57	–
(end July)	10–14	1281	62	4.8	7	54	1
	5–14	2987	134	4.4	22	111	1
1973	5–9	2081	178	8.5	54	124	–
(begin Aug.)	10–14	1064	85	7.9	35	50	–
After 2 cycles DDT	5–14	3145	263	8.3	89	174	–

It can be seen that there has been no decrease in the parasite rate but on the contrary an increase from 4.4 per cent (2987 ex.) in 1972 to 8.3 per cent (3145 ex.) in 1973. There has also been a significant increase of *P. falciparum* cases from 22 in 1972 to 89 in 1973. In the catching station the situation was similar the PR having increased from 8.3 (60) to 16.1 per cent (56).

In the unsprayed area the results can be summarized in table 2.

The increase of the parasite rate is sharper than in Panekan, and had survey No. 2 not been biased by excluding village Bogoarum, this increase would certainly have been much higher. In this unsprayed village an outbreak occurred during the seasonal recrudescence period May-June 1973 with a total of 249 cases

detected (of which 120 in June.).

Case detection: Limited surveillance activities are given in table 3 and illustrated in Fig. III. To summarize, the SPR in the Kecamatan (subdistricts) during the period January-July 1972 and 1973 was respectively :

Subdistrict	1972 per cent	1973 per cent
Panekan (sprayed)	3.8	4.3
Plaosan (unsprayed)	2.5	7.2

Table 2 Results in the unsprayed area of Plaosan (1972 and 1973)

Date	Age (years)	No. of slides Exam.	No. of slides Pos.	Per cent Pos	Parasite species F	Parasite species V
1972	5–9	975	3	0.3	2	1
(end July) .	10–14	1108	6	0.5	3	3
	5–14	2083	9	*0.4*	5	4
1973	5–9	1213	23	1.8	8	15
(begin Aug.)	10–14	630	6	0.9	2	4
	5–14	1843	29	*1.5*	10	19

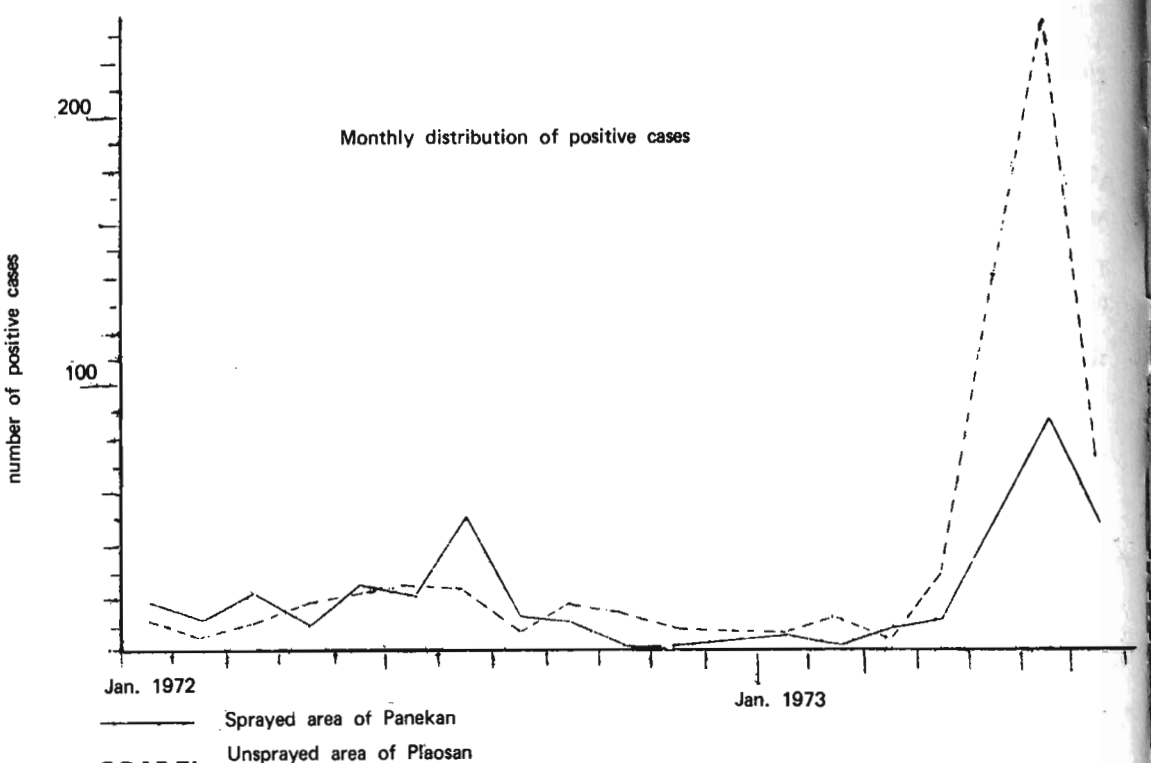

Fig. III. Case detection activities in Magetan special study area (East Java).

It can be seen that after spraying there has been a much steeper increase in the number of cases detected in the unsprayed area than in the sprayed one (this is due partly to better case detection in Plaosan).

Anyway, both from the serial parasite surveys and limited surveillance activities it can be seen that DDT has not prevented the seasonal recrudescence in the sprayed area (Panekan) but there has been a higher increase

Table 3 Results of case detection in Panekan and Plaosan, East Java (1972–1973)

Month	Panekan (sprayed)					Plaosan (unsprayed)				
	Exam.	Pos.	SPR per cent	Species f.	Species v.	Exam.	Pos.	SPR per cent	Species f.	Species v.
1. 1972	447	18	4.0	6	12	579	12	2.1	5	7
2.	566	11	1.9	7	4	598	5	8	2	3
3.	680	21	3.1	9	12	651	10	1.5	2	8
4.	352	10	2.8	6	4	805	18	2.2	10	8
5.	602	24	3.9	10	14	713	21	2.9	11	10
6.	273	19	6.9	6	13	396	24	6.1	8	16
7.	714	50	7.0	17	33	654	24	3.6	5	19
Subtotal before spray	3934	153	3.8	61	92	4396	114	2.5	43	71
8. 1972	460	13	2.8	5	8	487	7	1.4	3	4
9.	577	10	1.7	3	7	583	15	2.6	4	4
10.	1009	0	0	0	0	737	14	1.9	5	9
11.	252	0	0	0	0	379	9	2.4	3	6
12.	50	4	8.0	4	0	179	8	4.5	4	4
Total: 1972	5982	180	3.0	73	107	6761	170	2.5	62	108
1. 1973	459	6	1.3	4	2	679	7	1.0	4	3
2.	530	2	0.3	1	1	706	13	1.8	3	10
3.	538	8	1.5	–	8	780	4	0.5	1	3
4.	644	11	1.7	4	7	813	27	3.3	10	17
5.	840	50	5.9	8	42	1065	140	13.1	27	113
6.	873	86	9.8	16	70	1381	235	17.0	16	219
7.	861	45	5.2	20	25	1431	71	4.9	10	61
Subtotal: 1973	4745	208	4.3	53	155	6855	497	7.2	71	426

of cases in the unsprayed area (Plaosan). One factor which seems to have been determinent in the especially marked (but otherwise usual) seasonal increase of cases in 1973 is rainfall and humidity which was above usual in 1973.

Entomological studies.

Insecticide resistance: The mortality at 4 per cent DDT concentration was 21 per cent (78 specimens) in Tandjungsari (Panekan) in January 1972. The same degree of resistance was found in Bulukarjo 21 per cent (71 specimens) at 4 per cent DDT concentration in February 1972.

Man biting rate: The number of mosquitoes collected per man/night during the differenct months of the study (indoor and outdoor human-bait collections, according to the movement of the inhabitants) is summarized as follows:

Year	Month											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1972	–	7	22	52	*70*	30	13	7	2	1	1	4
1973	17	62	46	59	*92*	39	–	–	–	–	–	–

Due to the habits of the local population human bait collections were usually carried out from 6 pm until 20–21 pm outdoor, then until usually 5 am indoor and again outdoor from 5 to 6 am. Details show that after spraying there has been a decrease in indoor biting but an increase in outdoor biting. In other words there was a partial disruption of contact man/vector indoors. However as a result of especially favourable conditions in 1973 for the vector density and the habit of the population to stay outdoors from 5 am until 20 or 21 pm, the MBR has increased in 1973 despite spraying. Results of parous rates subject to erratic changes are difficult to explain.

Results of precipitin tests for the same period March–June were respectively 21 per cent (143 exam.) in 1972 and 18.5 per cent (631 exam.) in 1973. This show only a slight but not significant reduction because of the sample size. Outlet window traps were tried without success, confirming previous results (Chow et al. 1960).

Bantul (Yogyakarta)

Because of adequate case detection in this province, evaluation was based on surveillance activities, including active case detection, passive case detection and epidemiological investigations.

The area under total spraying coverage included a population of 60,00 (12,000 houses). Results of case detection in different areas of Yogyakarta in 1972–1974 and the details in the special study area during the period 1973–1974 are given in Table 4, 5 and illustrated in Fig. IV.

It can be seen from the above mentioned tables and figure that after total coverage in 1973 in the special study area there has been a marked decrease of cases from 323 indigenous in 1972 to 75 in 1973 and 19 for the first 8 months of 1974, moreover only 4 indigenous cases were detected during the period June–July–Aug. 1974 which usually concides with the yearly seasonal recrudescence peak. All 4 were *P. vivax*. The monthly BER was above 1 per cent. It can also be seen that in Bantul Regency, where extended focal spraying was

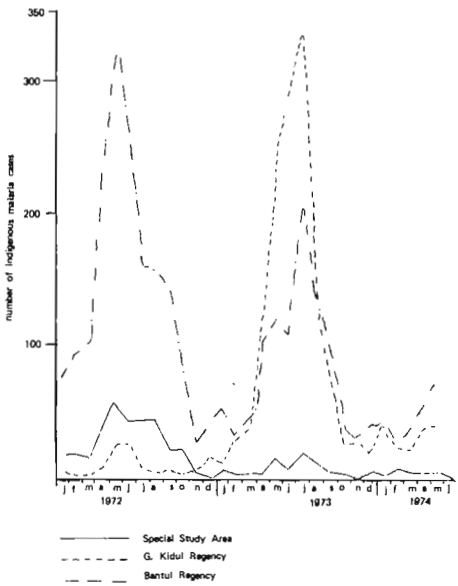

Fig. IV. Indigenous malaria cases in the special study area. The Bantul Regency and the G. Kidul Regency (Java).

carried out (each kampung with 2 indigenous cases), there was also a decrease of cases but less marked, while in the practically unsprayed Regency of Gunung Kidul there was an outbreak in 1973, the number of cases increasing from 98 in 1972 to 1336 in 1973.

A WHO susceptibility test was carried out in April 1973 in desa Sumberagung of Bantul, the mortality at 4 per cent DDT was only 4 per cent (138 specimens).

Other entomological activities were planned but for different reasons were not carried out. Drug resistance: An unexpected result of this study in Bantul was to reveal the first *P. falciparum* infections resistant to 4-aminoquinolines in Indonesia. These infections were suspected to be resistant because of repeated recrudescences despite radical treatments. All 4 suspect cases were imported from Kalimantan. Two of the 4 patients were submitted to carefully controled WHO field tests for *P. falciparum* strain sensitivity and shown to be resistant at the RI level. There were no other *falciparum* cases in the Kampungs and contacts were all negative, Heparinized and glycerolyzed blood samples were collected for strain characterization. Details are given in other reports.

Follow-up of other imported cases after radical treatment seems to indicate that drug resistance is absent from Java and South Sumatra.

Table 4 Results of case detection in different areas of Yogyakarta Province (1972–1973–1974)

Summary of results of case detection in 1972

Month	Special study			Bantul Regency			G. Kidul Regency			Yogyakarta Province		
	Exam.	Pos.	Indig.	Exam	Pos.	Indig.	Exam	Pos.	Indig.	Exam.	Pos.	Indig.
Jan.	1764	18	18	10081	83	75	8235	20	5	38054	184	120
Feb.	1702	17	17	10469	98	92	8581	12	1	36158	164	123
March	1548	14	13	10171	113	100	8710	33	1	36604	217	133
April	1547	40	38	11003	250	238	8300	44	7	35452	401	301
May	1491	58	57	12161	343	328	8899	98	25	39674	633	468
June	1443	46	43	10885	273	249	9378	96	26	40432	629	476
July	1406	49	45	9679	176	159	8659	66	6	37376	466	332
Aug	1272	50	44	8867	179	156	7662	40	3	33445	380	266
Sept.	1328	23	22	9530	158	141	8172	28	5	35819	364	272
Oct.	1946	25	22	11044	99	85	38226	26	2	38995	238	175
Nov	1251	3	3	9369	38	29	8637	19	3	36534	151	196
Dec.	1663	2	11	9701	53	42	9043	49	14	35138	165	94
Total:	18361	345	323	122960	1863	1694	102502	531	98	443681	3992	2856

Summary of results of case detection in 1973

Jan.	826	6	6	10705	63	52	9443	28	10	35005	170	121
Feb.	866	5	3	8701	42	31	8804	53	28	33095	187	113
March	736	7	4	7334	55	43	10800	104	39	33993	249	139
April	741	3	3	8453	120	101	11309	266	124	35708	578	329
May	954	18	15	9364	157	118	16640	513	242	45761	994	535
June	992	5	4	9728	143	106	17310	526	289	46797	1010	608
July	1352	28	19	9951	234	202	18267	526	331	46766	1089	727
Aug.	1261	18	11	9504	191	137	14513	282	139	41854	788	451
Sept.	894	9	4	7814	141	91	11778	167	63	35825	538	262
Oct.	693	5	2	6640	84	37	10796	123	27	31890	350	120
Nov.	648	3	–	6399	64	31	10346	76	25	31532	274	112
Dec.	699	6	4	7655	55	38	9685	73	19	31993	273	115
Total:	10662	113	75	102248	1371	987	149691	2737	1336	451099	6508	3632

Summary of results of case detection in 1974 (up to July)

Jan.	843	10	3	7118	90	41	10238	129	43	32877	394	174
Feb.	913	9	5	6469	49	27	9221	88	24	30460	271	114
March	782	6	3	7568	64	37	10039	81	20	33244	293	114
April	941	3	2	9975	80	55	11552	128	36	40375	359	163
May	1108	4	2	11289	98	70	12243	124	38	43469	421	208
June	954	3	0	9488	94	47	11344	118	43	38865	420	186
July	856	8	2	8203	81	44	10806	98	18	34108	371	135
Subtotal: (July)	6397	43	17	60110	556	321	75443	766	222	253398	2529	1094

Table 5 Results of case detection in the special study area of Yogyakarta

Summary of results of case detection in the special study area in 1973

Month	Exam.	Pos.	Species			Classification				Age group				
			F	V	Mix.	Ind.	Rel.	Imp.	Uncl.	1	1–4	5–9	10–14	15+
Jan.	826	6	5	1	–	6	–	–	–	–	–	1	–	5
Feb.	866	5	3	2	–	3	–	2	–	–	–	–	2	3
March	736	7	4	2	1	4	–	2	1	–	1	1	–	5
April	741	3	3	–	–	3	–	–	–	–	–	1	–	2
May	954	18	7	11	–	15	–	3	–	1	5	3	–	9
June	992	5	5	–	–	4	1	–	–	–	–	–	1	4
July	1352	28	13	14	1	19	3	6	–	–	1	2	5	20
Aug.	1261	18	7	10	1	11	3	4	–	–	3	3	1	11
Sept.	894	9	6	2	1	4	3	2	–	–	–	1	2	6
Oct.	693	5	3	2	–	2	2	1	–	–	1	–	–	4
Nov.	648	3	–	3	–	–	–	3	–	–	–	–	–	3
Dec.	699	6	2	4	–	4	1	1	–	–	1	1	1	3
Total:	10662	113	58	51	4	75	13	24	1	1	12	13	12	75

Summary of results of case detection in the special study area in 1974

Month	Exam.	Pos.	Species			Classification				Age group				
			F	V	Mix.	Ind.	Rel.	Imp.	Uncl.	1	1–4	5–9	10–14	15+
Jan.	843	10	5	5	–	3	2	5	–	–	1	1	1	7
Feb.	913	9	1	8	–	5	–	4	–	–	–	–	1	8
March	782	6	1	5	–	3	–	3	–	–	–	2	–	4
April	941	3	1	1	1	2	–	1	–	–	–	1	1	1
May	1108	4	3	1	–	2	–	2	–	–	–	–	–	2
June	954	3	–	3	–	0	1	2	–	–	–	1	–	2
July	856	8	2	6	–	2	–	6	–	–	1	1	1	5
Aug.	680	3	–	3	–	2	1	–	–	–	–	1	–	2

DISCUSSION

A. aconitus has strong zoophilic and exophilic tendencies and transmits an unstable type of malaria characterized by regular epidemics (annual seasonal recrudescences) associated with the multiplication of breeding places during the peak of the rice season.

DDT is very effective when the mosquito is susceptible. On the other hand, once resistant to DDT, mortality becomes negligible after a very short time after spraying (2 weeks) as shown by Soerono and Muir*. However, there may still be some action resulting from the modification of the man biting habit (itself resulting from the disruption of man/vector contact) the basic reproduction rate varying with its square. There may also be a secondary but not very significant efffect on longevity due to decreased indoor restingg.

In Magetan (special study area of East Java) where man and cattle live practically under the same roof the deviation is expected to be much less than in Yogyakarta where cattle stay in well separated and largely open cowsheds (in a group of villages from Yogyakarta area it is was also shown that transmission continued among people sleeping in untreated cowsheds). See figures V, VI, VII and VIII.

* On the other hand the mortality with malathion was still 84% after 4 months.

MAN AND CATTLE IN THE TWO STUDY AREAS.

Fig. V. In Magetan (East Java) man and cattle live practically under the same roof. (In this house cattle spend the night indoors in the right side of the house, separated from man only by a thatched fence, one meter high).

Fig. VI. In Yogyakarta (Central Java) cattle stay in well separated and largely opened cowsheds.

SOME FACTORS WHICH MAY EXPLAIN SOME RESIDUAL TRANSMISSION IN YOGYAKARTA.

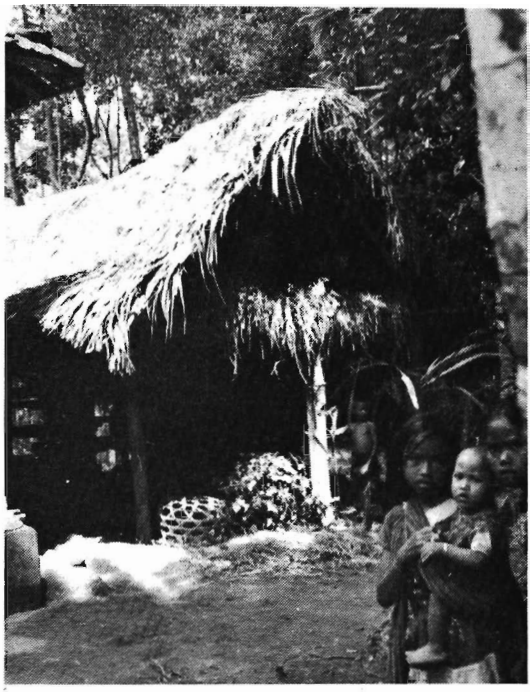

Fig. VII. In a group of villages from Yogyakarta area it was shown that transmission continued among people sleeping in untreated cowsheds.
This picture shows the space under the roof of the cowshed where in some villages people may sleep at night, to prevent the cattle being stolen.

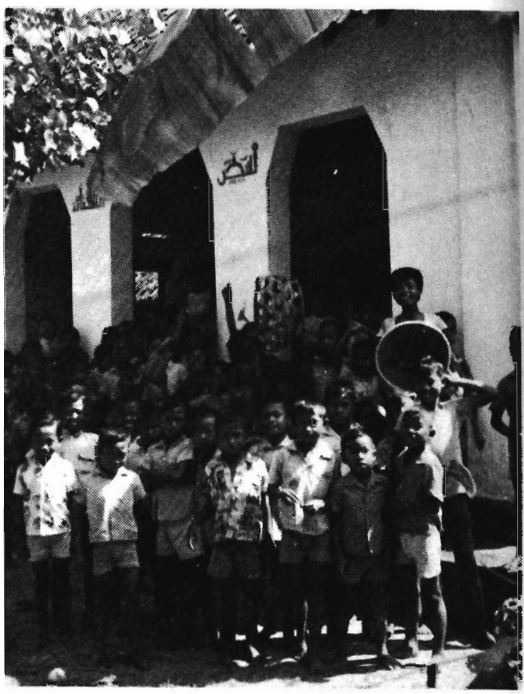

Fig. VIII. Epidemiological investigations also indicated that some residual transmission continued among people staying late at night in largely open and unsprayed mosques such as this one. Chlidren may sleep there and spend all the night.
(Mosques are not allowed to be sprayed).

DDT removal is also more marked in Magetan especially in better class houses with carved wooden walls. These factors may explain the relatively good results obtained in Bantul special study (Yogyakarta) which contrast with the poor results of the Magetan special study (East Java). It must therefore be assumed that local conditions are likely to be mainly responsible for the difference.

Where cattle are abundant and kept separated from man a relatively minor disruption of the contact man/vector may be sufficient to control transmission (there may even be anophelism without malaria, especially if the mosquito density is low). On the other hand where cattle are scarce and/or living in close contact with man, the disruption of contact with man may be negligible or at least insufficient to give a satisfactory control of transmission. It is under these conditions that another insecticide which inflicts a high mortality on the vector should be used.

To delimit such areas for subsequent implementation of an alternative insecticide would reflect the wisest policy at present. Of course an alternative insecticide such as malathion, would also be highly effective in areas of the Bantul type but the cost may be prohibitive under present economic conditions, especially considering that the programme is a MCP without definite time limits.

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